# Multisplitter Calculator

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*Abstract.* In this WF note, I follow up on the previous work done in WF-198. The main question I want to address is: If the RBT ratio is wrong due to slight imperfactions in the plate-type, beamsplitter optics, can the ratio be corrected by adding neutral density filters (NDF) as shown in WF-198.

**1. Enter measured (or desired) values of intensity ratios from first to last and NDF values**

$$\text{measuredR} := \begin{pmatrix} 1 \\ 3 \\ 5 \\ 7.1 \end{pmatrix} \qquad \text{idealR} := \begin{pmatrix} 1 \\ 3 \\ 5 \\ 7 \end{pmatrix}$$

**2. normalize**

$$\text{RM} := \frac{\text{measuredR}}{\max(\text{measuredR})} \quad \text{RM} = \begin{pmatrix} 0.14085 \\ 0.42254 \\ 0.70423 \\ 1 \end{pmatrix} \qquad \text{RI} := \frac{\text{idealR}}{\max(\text{idealR})} \quad \text{RI} = \begin{pmatrix} 0.14286 \\ 0.42857 \\ 0.71429 \\ 1 \end{pmatrix}$$

**3. Using Equation 3 from WF-198 solve for x1, x2 and x3**

Guess values: $x1 := 0.1 \quad x2 := 0.1 \quad x3 := 0.1$

Given

$$x1 \cdot x3 = RM_0 \qquad \frac{x1}{x2} = RM_1 \qquad \frac{x3}{x2} = RM_2$$

$$\begin{pmatrix} x1val \\ x2val \\ x3val \end{pmatrix} := \text{Find}(x1, x2, x3)$$

Results:

$$x1val = 0.2907 \quad x2val = 0.68799 \quad x3val = 0.4845$$

Check solution:

$$x1val \cdot x3val = 0.14084 \qquad \frac{x1val}{x2val} = 0.42254 \qquad \frac{x3val}{x2val} = 0.70423$$

$$RM_0 = 0.14085 \qquad RM_1 = 0.42254 \qquad RM_2 = 0.70423$$

**4. Find transmission (T) and reflection (R) for each mirror**

Guess values: $t1 := 0.1 \quad t2 := 0.1 \quad t3 := 0.1$

Given

$$\frac{t1}{1 - t1} = x1val$$

$$\frac{t2}{1 - t2} = x2val$$

$$\frac{t3}{1 - t3} = x3val$$

$$\begin{pmatrix} t1val \\ t2val \\ t3val \end{pmatrix} := Find(t1, t2, t3)$$

Results:

| TRANSMISSION T | REFLECTION R |
|---|---|
| $t1val = 0.22523$ | $1 - t1val = 0.77477$ |
| $t2val = 0.40758$ | $1 - t2val = 0.59242$ |
| $t3val = 0.32637$ | $1 - t3val = 0.67363$ |

**5. Given the actual values of T and R can I add NDF's to get the ideal ratio back?**

Guess values:

$a := 1.0 \quad b := 1.0 \quad c := 1.0 \quad d := 1.0$

***Ideal***

$RI_0 = 0.14286 \quad RI_1 = 0.42857 \quad RI_2 = 0.71429 \quad RI_3 = 1$

***actual intensities with NDF's***

$$Int := \begin{bmatrix} b \cdot c \cdot t1val \cdot t2val \cdot t3val \\ b \cdot d \cdot t1val \cdot (1 - t2val) \cdot (1 - t3val) \\ a \cdot c \cdot (1 - t1val) \cdot (1 - t2val) \cdot t3val \\ a \cdot d \cdot (1 - t1val) \cdot t2val \cdot (1 - t3val) \end{bmatrix}$$

$\frac{Int_0}{Int_3} = 0.14084 \quad \frac{Int_1}{Int_3} = 0.42254 \quad \frac{Int_2}{Int_3} = 0.70423$

$1 \cdot Int_0 = 0.02996 \quad 1 \cdot Int_1 = 0.08988 \quad 1\,Int_2 = 0.1498 \quad 1 \cdot Int_3 = 0.21272$

Given

$b \cdot c \cdot t1val \cdot t2val \cdot t3val = 0.03014$

$b \cdot d \cdot t1val \cdot (1 - t2val) \cdot (1 - t3val) = 0.09043$

$a \cdot c \cdot (1 - t1val) \cdot (1 - t2val) \cdot t3val = 0.15071$

$a \cdot d \cdot (1 - t1val) \cdot t2val \cdot (1 - t3val) = 0.211$

$$\begin{pmatrix} aVal \\ bVal \\ cVal \\ dVal \end{pmatrix} := Find(a, b, c, d)$$

$Find(a, b, c, d) =$

Results:

$x1val = 0.2907 \quad x2val = 0.68799 \quad x3val = 0.4845$

Check:

$I1 := bVal \cdot cVal \cdot t1val \cdot t2val \cdot t3val \qquad I2 := bVal \cdot dVal \cdot t1val \cdot (1 - t2val) \cdot (1 - t3val)$

$I3 := aVal \cdot cVal \cdot (1 - t1val) \cdot (1 - t2val) \cdot t3val \quad I4 := aVal \cdot dVal \cdot (1 - t1val) \cdot t2val \cdot (1 - t3val)$

$I1 = 0.03051 \quad I2 = 0.09031 \quad I3 = 0.15064 \quad I4 = 0.21105$

$\frac{I1}{I4} = 0.14455$ $\frac{I2}{I4} = 0.42788$ $\frac{I3}{I4} = 0.71373$

$RI_0 = 0.14286$ $RI_1 = 0.42857$ $RI_2 = 0.71429$

aVal = 1.0238

bVal = 1.03675

cVal = 0.98219

dVal = 0.96911

These are the values of NDF's needed.